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NEW LOADER AND TRUCK PAYLOAD MEASUREMENT SYSTEMS

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August, 1988

This document is a report
prepared and written
for the
Energy, Mines and
Resources Canada
by
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Division des minéraux et de
l'énergie (CANMET)

16 pp
COAL RESEARCH LABORATORIES
DIVISION REPORT CRL 88-50 (TR)

MICROMEDIA

NEW LOADER AND TRUCK PAYLOAD MEASUREMENT SYSTEMS

by

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ABSTRACT

During the Minexpo International '88, held in Chicago, Ill. in April 1988, two manufacturing companies introduced new payload measurement systems. Caterpillar from Peoria, Ill. introduced PMS (Payload Measurement System) for their line of off-highway trucks, and Marathon Letourneau introduced VSM (Vital Signs Monitor plus Load Weighting System) for their L-1000 loaders and Titan - 2000 series trucks.

In this report both systems are explained.

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NOUVEAUX SYSTÈMES DE MESURE DE LA CHARGE UTILE
DES CAMIONS ET DES CHARGEUSES-PELLETEUSES

par

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RÉSUMÉ

Pendant la Minexpo internationale '88 qui s'est déroulée en avril 88 à Chicago, Ill., deux sociétés industrielles ont présenté de nouveaux systèmes de mesure de la charge utile. La société Caterpillar de Peoria, Ill. a mis au point un système de mesure de la charge utile (PMS) pour sa flotte de camions tous-terrains. Marathon Letourneau a présenté un système de contrôle avec indicateur d'occupation doté d'un dispositif de pesée de la charge (VSM) développé pour la chargeuse L-1000 et les camions Titan de la série 2000.

Les deux systèmes de mesure de la charge utile sont décrits dans ce rapport.

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INTRODUCTION

There are two different approaches to monitor quantities of material being moved at surface mines. One is monitoring the load at the loading equipment, the second is monitoring truck payload. Both systems have advantages and disadvantages. In the past automatic load measurement for loading equipment has been tested unsuccessfully at several surface coal mines in Canada (Lornex, Cardinal River, Gregg River, etc.). Truck load monitoring systems were introduced by several truck manufacturing companies in the past (Terex, Unit Rig, Komatsu), or by truck accessories companies (Philippi-Hagenbuch). Only one system, OBDAS, developed by Philippi-Hagenbuch is operational at present at the Gregg River mine.

Two new systems were introduced at the Minexpo '88 mining show held in Chicago in April 1988. One is PMS (Payload Monitoring System) developed for Caterpillar off-highway vehicles, another is VSM (Vital Signs Monitor and Load Weighing System) developed for Marathon Letourneau L-1000 loaders and Titan - 2000 series trucks. Both systems are introduced in this report.

CATERPILLAR'S PMS SYSTEM

Components of the System.

The Truck Payload Measurement System consists of the payload measurement control (PMC) electronic module, and the payload operator's display (POD) module, four strut pressure sensor units, left and right external loading indicator lights, and the harnesses. In addition to this hardware, the bed-raise switch, the transmission speed distributor, and the neutral start control are utilized as input to the system.

The PMC module reads the vehicle status inputs, processes them, records the results, and controls the outputs. The PMC module is located on the left side of the operator compartment, behind the seat.

Recorded vehicle status inputs are:

1. The bed-raise switch.

This signal tells the PMC when the body is being raised and the contents being dumped. The switch is located on the left side of the operator compartment, behind the seat.

2. The transmission speed distributor.

This signal provides vehicle speed to the PMC, it tells when the truck is stopped or moving, it knows the speed of the vehicle. The distributor is located inside the center console in the operator compartment. The access to it is not easy, a panel on the console must be removed for access.

3. The neutral start control.

This signal tells the PMC when the transmission is in neutral. The control is located on the front wall inside the centre console in the operator compartment.

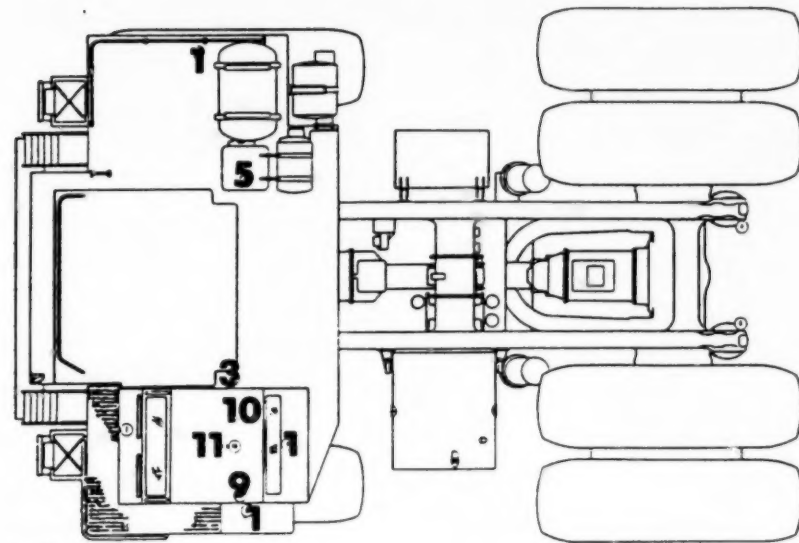
4. The four strut pressure sensor.

Each of these four sensors provide the payload measurement control with a signal that is directly proportional to the pressure in the respective strut. The sensor is mounted at the top of each strut cylinder.

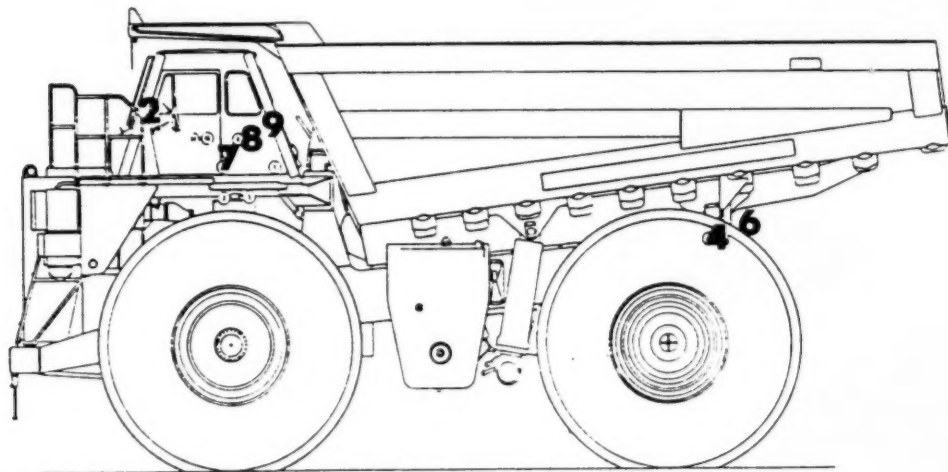
By having these signal as inputs, the PMC can process this information and monitor the truck as it goes through its entire cycle.

Data obtained from each cycle is retained by the PMC in a non-volatile memory, allowing the user to extract this information later on. The memory allows data (up to 890 cycles) to be stored indefinitely. When the data is extracted the memory is erased and ready to begin storing new data.

The location of components of the truck payload measurement system are shown in Fig. 1.



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Component Location

(1) Payload measurement control (PMC); (2) Payload operator's display (POD); (3) Right front strut pressure sensor; (4) Right rear strut pressure sensor; (5) Left front strut pressure sensor; (6) Left rear strut pressure sensor; (7) Right external indicator lights; (8) Left external indicator lights; (9) Bed raise switch; (10) Transmission speed distributor; (11) Neutral start control.

Fig. 1. PMS - Component Location

Operation and Display.

Outputs from the PMC are the two vehicle displays; the payload operator display (POD) in the cab, and the external loading indicator lights. The POD is mounted in the dash and consist of three-digit liquid crystal display (LCD) used to indicate the weight of the load in the body. The dash mounted display has also two LED (one red, one green). These two LED's duplicate the activity of the external load indicator lights. The external indicator lights are used to inform the loader and truck operators that:

1. Load is detected.
2. The maximum load is detected.

Calculating the weight of material in the body of the truck is based upon measuring the difference between empty and loaded strut pressures. Thus the payload calculated, displayed on the POD and recorded in the memory is the true payload, neglecting fluctuations in the weight of fuel and dirt accumulated on the body and frame.

Once the vehicle starts moving, the PMC begins keeping track of the time and speed. The distance traveled can be calculated when the vehicle comes to a stop. This data is retained in a temporary memory until completion of a cycle.

Bed-raise switch actuation tells the PMC that one cycle has ended and another is beginning. When the bed-raise switch is opened, this indicates that the operator is raising the body and dumping the load. For the first cycle it is assumed by the PMC that the bed is empty and the following activity is the start of a load cycle. The truck is also calibrated every time when it is stopped and empty. The payload is adjusted for changes in the truck tare weight due to mud build up, fuel consumption and temperature effect on components.

The green external loading indicator lights will not be activated until the truck is stopped, the transmission is in neutral, the parking

brake is on, and the first payload is greater than 9 tonnes. A green light tells the loader operator that a load is detected and that the system is working correctly. The POD shows dashes until the load in the body reaches the weight shown for each model (for example 91 tonnes for Cat 789 model). When the weight is reached, the digital display begins showing the actual tonnage in the body. If truck is partially loaded and moved less than 150 m and then is fully loaded, the PMC will record only as one load. The maximum weight setting range is listed in Table 1.

Table 1. PMS - Maximum Weight Setting Range

Maximum Weight Setting Range			
Truck Model	Rated Maximum	Minimum Setting	Maximum Setting
769C	32 Metric Ton (35 U.S. Ton)	27 Metric Ton (30 U.S. Ton)	36 Metric Ton (40 U.S. Ton)
773B	45 Metric Ton (50 U.S. Ton)	36 Metric Ton (40 U.S. Ton)	54 Metric Ton (60 U.S. Ton)
777B	77 Metric Ton (85 U.S. Ton)	63 Metric Ton (70 U.S. Ton)	91 Metric Ton (100 U.S. Ton)
785	118 Metric Ton (130 U.S. Ton)	100 Metric Ton (110 U.S. Ton)	136 Metric Ton (150 U.S. Ton)
789	154 Metric Ton (170 U.S. Ton)	132 Metric Ton (145 U.S. Ton)	177 Metric Ton (195 U.S. Ton)

The payload measurement system is programmed using the different display modes. The mode select switch is used to access these various display modes. However, the mode select switch is not accessible to the operator. The eight display modes and a explanation of each is given below.

Mode 0 - Payload mode.

This is the normal POD display mode used for displaying payload weights, the power-up test, and any faults that occur during day-to-day operations.

Mode 1 - Truck model setting mode.

This mode is used to input the truck model number, because the truck payload measurement system is programmed for various Caterpillar trucks types.

Mode 2 - Display units mode.

This mode is used to program the truck payload measurement system for displaying and recording data in imperial or metric units.

Mode 3 - Maximum load weight mode.

This mode is used to select the desired maximum allowable weight range. The range is defined as 85 to 115 percent of the truck's rated payload.

Mode 4 - Truck fleet identification number mode.

This mode allows the user of the system to assign an identification number to each truck in the fleet.

Mode 5 - System options mode.

This mode is used to select options of the PMC for the intended application, such as the external loading lights status, POD digital readout status, type of communication, etc. The available options are listed from 001 to 024 in the set-up procedure.

Mode 6 - Calibration mode.

This mode is used when the system is first installed, or after any strut service is done. The PMC baseline strut pressures for the empty truck are recorded during calibration mode. When the calibration is done, the PMC assumes the truck to be empty, clean, and the struts to be properly charged.

Mode 7 - System status mode.

This mode is used as a built-in service tool for troubleshooting the system. Capability for isolating both intermittent and hard faults is provided.

The mode description with corresponding number is summarized in Table 2. The system option settings is summarized in Table 3.

Table 2. PMS - Node Codes.

Mode Number	Mode Description	Mode Select Switch Depressions from Mode -0-
-0-	Payload display	None (powerup)
-1-	Model setting display	1
-2-	Units setting display	2
-3-	Maximum weight setting display	3
-4-	Truck I.D. code setting display	4
-5-	System options setting display	5
-6-	Zero calibration setting display	6
-7-	System status display	7
-0-	Payload display	8

Table 3. PMS - System Option Setting.

System Option Settings					
Option Setting	Display Payload Enabled ? (¹)	External Loader Lights Enabled ?	One Pass Indicator Enabled ? (²)	Auto Broadcast Enabled ?	Baud Rate (³)
o01	Yes	Yes	No	No	9600
o02	No	Yes	No	No	9600
o03	Yes	Yes	Yes	No	9600
o04	No	Yes	Yes	No	9600
o05	Yes	No	No	No	9600
o06	No	No	No	No	9600
o07	Yes	Yes	No	Yes	9600
o08	No	Yes	No	Yes	9600
o09	Yes	Yes	Yes	Yes	9600
o10	No	Yes	Yes	Yes	9600
o11	Yes	No	No	Yes	9600
o12	No	No	No	Yes	9600
o13	Yes	Yes	No	No	1200
o14	No	Yes	No	No	1200
o15	Yes	Yes	Yes	No	1200
o16	No	Yes	Yes	No	1200
o17	Yes	No	No	No	1200
o18	No	No	No	No	1200
o19	Yes	Yes	No	Yes	1200
o20	No	Yes	No	Yes	1200
o21	Yes	Yes	Yes	Yes	1200
o22	No	Yes	Yes	Yes	1200
o23	Yes	No	No	Yes	1200
o24	No	No	No	Yes	1200

¹ Display payload - POD payload display enabled?² One pass indicator - red flashing light enabled?³ Baud rate - transmit and receive baud rate for external communication devices.

MARATHON LETOURNEAU VSM SYSTEM

System Functions

The Marathon Letourneau Company, heavy equipment division, from Longview, Texas, has introduced a vital sign monitoring system (VSM) for their loaders. The company claim that with slight modification the system may be used for other similar heavy duty equipment, including off-highway trucks. The Titan T-2000 series were mentioned as an example.

The VMS consists of a digital display, information gathering sensors and a 16-bit microprocessor, called the remote processing unit (RPU).

The RPU continuously scans up to 96 different inputs 250 times per second. If out-of-limit or alarm conditions are detected, the system sounds an alarm for the operator, so that corrective action may be taken immediately. An up-to-date information on alarm conditions is stored and may be released on demand. This is vital for precise troubleshooting, failure and trend analyses. Even if there is no alarm condition, every half hour the computer records the instantaneous operating inputs, time and date, and stores this information in memory.

At any time the operator can determine the condition of any input by scanning the digital display. Alarm conditions are clearly shown on the digital display in both words and numbers. When an alarm occurs, the buzzer sounds and the red light remains on until the operator acknowledges the alarm.

The specification of the system is summarized in the Table 4.

Table 4 - VSM - System Specification.

Display	
Display type	Vacuum fluorescent, 20 character alphanumeric
Dimensions	44.75 * 9.0 * 11.5 cm
Operator switch type	High impact, individual switches
Input voltage	24 V, DC machine voltage
Remote Processing Unit	
Inputs	48 digital max, 40 analog max.
Dimensions	45.75 * 42.0 * 29.5 cm
Operating range	Ambient temperature -25 to 65 deg. C.

The VSM system is capable of monitoring these typical vital signs:

- horsepower,
- traction motor voltage, current, temperature, RPM, direction,
- engine RPM,
- fan speed switch,
- armature converter temperature,
- field converter temperature,
- voltage regulator temperature,
- generator temperature,
- motor field current,
- armature converter failure,
- field converter failure,
- voltage regulator failure,
- ground fault alarm,
- dynamic retard failure,
- vehicle speed,
- generator voltage,
- traction motor cooling air switch,

- engine temperature switch,
- hydraulic oil temperature switch,
- electric cabinet door open alarm,
- low fuel level switch,
- loss of battery alternator relay,
- hydraulic tank alarm switch,
- brake pressure differential alarm switch,
- steer/brake system pressure alarm switch,
- engine oil level and pressure switch,
- engine coolant level and temperature switch,
- crankcase pressure switch,
- coolant pressure switch, and
- air filter restriction switch.

In addition to the above, the system may be also programmed to accommodate additional sensors, if requested by users, for example monitoring service brake use, control of downhill speed on haul roads, etc.

The supplier claims that with the use of VSM system, the mine operator may:

- prevents costly equipment failures,
- reduces downtime and increases equipment availability by up to 10 percent,
- makes maintenance scheduling easier and cost effective,
- gives management immediate access to operating conditions,
- speeds and simplifies troubleshooting, and
- provides information for trend and failure analyses.

Optional Load Weighing System

The Letourneau's Load Weighing System (LWS) is an option available for L-1000 type loaders and may also be requested for Titan-2000 series off-highway vehicles. It consists of multiple sensors located under the bed, that register the accumulated weight. The LWS ensures that each load attains the truck's design load limit for greater productivity. It also prevents

overloads for less equipment wear and tear, longer equipment life and less maintenance. A real-time link to the central dispatch system may be made available for immediate access to load information.

The optional LWS is used in conjunction with the VSM system. It can be used on its own, or can be tied into the VSM as a companion module. An optional three lamp light assembly informs a loader operator when designed payload weight limit has been reached.

The LWS installed on loaders weighs each bucket separately and accumulates weight until the indicator shows that the truck is full. The total weight and number of buckets are then stored in system memory for further retrieval. The accuracy of the loader weighing system was not specified. It is understood that it may range ± 20 percent of the individual load, depending on the terrain where the loader is operating. It is recommended that the loader operator stops with the load for 5 to 10 seconds on the flat for better accuracy.

CONCLUSION

The Caterpillar's Truck Payload Measurement System (PMS) and LeTourneau's Vital Signs Monitoring System (VSM) and Load Weighing System (LWS) were exhibited at the Chicago's mining show Minexpo 88 in April 1988. In this report, both systems are described using information from the suppliers.

REFERENCES

1. "Truck Payload Measurement System", information bulletin issued by Caterpillar, Peoria, Ill., Form No. SENR3537, 1988.
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